Biofueled CHP - Economic synergy effects resulting from cooperation between industry and energy utility companies

Å. Marbe*, S. Harvey, T. Berntsson
Heat and Power Technology, Chalmers University of Technology, Gothenburg, Sweden
Fax: +46-31-821928; asa.marbe@hpt.chalmers.se

Introduction
Many technical, economic, political and organizational factors influence profitability of biofueled CHP. Examples of important factors are fuel costs, investment cost, tax rates and technical performance. One way to increase opportunities for biofuel CHP is cooperation between industry and district heating utility companies. Such cooperation can profit from both the higher total efficiency resulting from the delivery of low-grade heat to the district heating system and the longer annual operating time that generally be accomplished in industry. The goal of this study is to investigate how cooperation between industry and energy utility companies can improve profitability of biofueled combined heat and power plants. The type of cooperation investigated is co-ownership of a single CHP plant delivering heat and power to both owners. Future advanced CHP technologies that produce significantly more power than conventional technology are included in the study. Both technical and economic parameters are studied.

Methodology
The different biofuel-fired heat and power production technologies that are examined are:
- ?? Conventional biofuel boiler with a steam turbine
- ?? Atmospheric biofuel integrated gasification connected to either a simple cycle gas turbine or combined cycle. The fuel is dried in an integrated flue gas dryer.
- ?? Pressurized biofuel integrated gasification connected to either a simple cycle gas turbine or a combined cycle. The fuel is dried in an integrated flue gas or steam dryer.

The technologies are then compared on the basis of their respective electricity production costs. The cost of electricity for the different technologies is calculated based upon a heat credit. This credit is based upon the total annual heating costs for the cheapest alternative heat only system. The calculations are done with Swedish fuel costs and fuel taxes for industrial and general applications. The calculations are based upon data for the heat demand for Katrinefors Kraftvärmeverk in Mariestad, Sweden. The heat demand duration curve used includes both the steam demand for a recycled fibre paper mill and the heat demand for Mariestad´s district heating network. The calculations are performed first for a separate CHP plant that supplies the industrial heat demand (steam) only, then for a separate plant that supplies the district heating only, and finally for a single joint owned CHP plant that supplies heat both to the industry and district heating network as is the case in Mariestad.

The industrial case is calculated with a relatively high annuity factor (0.2). The heat demand is essentially constant over the year, which results in a long annual operation time for the CHP plant. The total efficiency is relatively low. In the district heating case the annual factor is lower (0.1) than in the industrial case. The annual operation time is short because the heating demand is variable over the year, but the total efficiency is high because it is possible to extract more heat from the flue gas. In the case combining the industrial and district heating heat demands, the advantages of the two systems are combined, i.e:
- ?? The annual operation time for the CHP plant is longer than for the district heating case as a result of the essentially constant industrial heat load;
- ?? The total efficiency is high for a significant fraction of the year as a result of the possibility to deliver low temperature heat to the district heating system.

Results

Of the studied technologies, conventional biofueled steam turbine CHP is the most cost-efficient technology in the district heating application and in the cooperation case with a CHP plant that supplies heat to both an industry and district heating network. For the industrial application the pressurized biofuel integrated gasification with combined cycle is the most cost efficiencies technology. However, in the industrial application the cost of electricity is too high to be competitive under current condition on the deregulated Scandinavian power market, 0.60 – 0.63 SEK/kWh (0.06 – 0.063 USD/kWh) *). The cost of electricity for a conventional steam cycle and the cheapest and most expansive gasification technology respectively for the case when a CHP plant supplied both a industry and district heating network with heat is illustrated in figure 1.
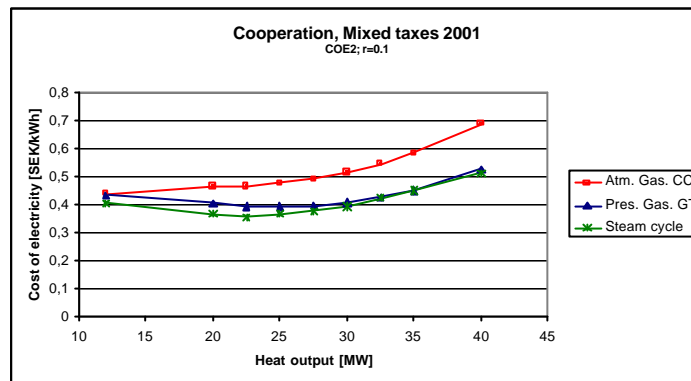

Figure 1:   Cost of electricity for a conventional steam cycle and the cheapest and most expensive gasification technology for a jointly-owned CHP plant supplying heat to both a process industry and a district heating network.

As a result of the synergy effects, the cost of electricity is lowest when the CHP plant supplies heat both to an industry and a district heating network, for all studied technologies. For example the cost of electricity from a conventional steam turbine is in the range 0.62 – 0.57 SEK/kWh for industrial CHP power production and 0.68 – 0.94 SEK/kWh for district heating CHP power production for, compared to 0.35 – 0.51 SEK/ kWh for CHP power plant supplying heat to both the industry and the district heating network (cooperation), see Figure 2a). The cost of electricity for the same three applications when the electricity is produced by the cheapest gasification technology (pressurized biofuel integrated gasification with a simple gas turbine cycle), is shown in Figure 2b.
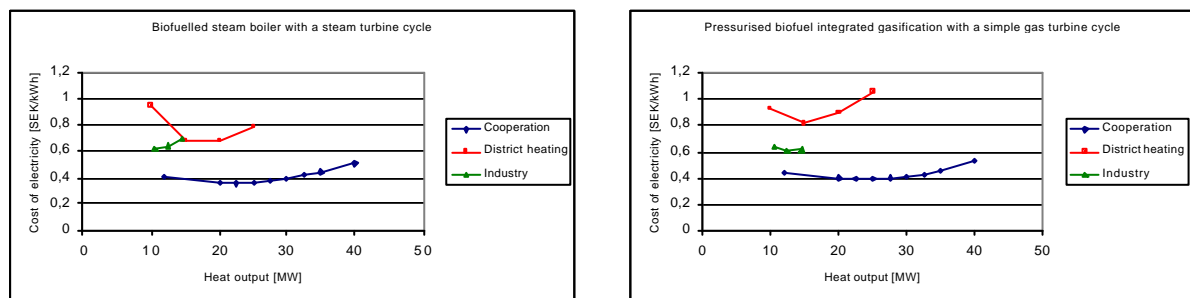

Figure 2:   Cost of electricity produced in a CHP plant that supplies heat to an industry, a district heating network or both an industry and a district heating network (cooperation). The electricity is produced in a) conventional steam cycle and b) pressurized biofuel integrated gasification with a gas turbine.

*) The calculations are done in Swedish crowns (SEK), 1USD ~ 10 SEK.